Potassium Carbonate Handbook

Background

In 1986, two strong manufacturers in the chemical industry combined in a joint venture to form the Armand Products Company... the leading producer and marketer of potassium carbonate and potassium bicarbonate in the world.

From the Occidental Chemical Corporation came the manufacturing capability for the production of the highest quality chemicals, with marketing and technical service expertise for product support.

From the Church & Dwight Co., Inc. came the sales and R&D functions to maintain the high level of customer service that our customers require.

As a market leader, the Armand Products Company provides the facilities and manpower needed to meet the requirements of our customers. Our two plants and four reactors run in the continuous mode, assuring an uninterrupted supply of potassium carbonate. An additional reactor is dedicated to the production of potassium bicarbonate. This manufacturing facility is located in Muscle Shoals, AL.

Armand Products Company has full integration with a dedicated production source of potassium hydroxide, the key raw material for making potassium carbonate. Potassium bicarbonate is produced by further carbonation of potassium carbonate. The Tennessee Valley Authority (TVA), one of the largest electricity generators in the United States, supplies power to the Muscle Shoals facility at a reasonably stable cost.

Current capacity is 108,000 short tons/year for potassium carbonate and 5,000 short tons/year for potassium bicarbonate. This places Armand Products as the largest domestic and international source of potassium carbonate, as well as the only producer of potassium bicarbonate in the U.S.

In order to meet the requirements of the many diverse applications, each product is available in several different grades. Various package forms are also available, ranging from bags to railcars. Smaller packages are available directly from the plant or at many warehouse and distribution points across the country.

Armand Products' commitment to quality and consistent performance is shown in its continued good standing as an ISO 9002 certified and OSHA Star facility.

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All recommendations and suggestions appearing in this booklet concerning the use of our products are based upon tests and data believed to be reliable. However, as the actual use of our products by others is beyond our control, no guarantee, expressed or implied, is made as to the effects of such use, or the results to be obtained, whether or not any use of our products is made in accordance with recommendations or suggestions contained in this handbook or otherwise. Furthermore, information on the use of our products is not to be construed as recommendation to use such products in the infringement of any patent. These suggestions should not be confused either with state, municipal, or insurance requirements, or with national safety codes.

Introduction

Potassium carbonate is one of the most important inorganic compounds used in industry even though it is as old as recorded history. Potassium carbonate was leached from ashes in Pompeii and mixed with slaked lime for soapmaking. The increase in the use of this alkali paralleled the growth of western civilization. So much wood was consumed in the production of potassium carbonate that the forests of Europe were threatened. At the time of the French Revolution, LeBlanc's invention allowed sodium carbonate to be substituted on a general basis.

The potassium carbonate that was recovered from ashes became the prime potassium compound before 1870. During these early times, potassium hydroxide (KOH, caustic potash) was made from potassium carbonate by reaction with calcium hydroxide. However, the recovery of potassium chloride in 1860 from "rubbish salt" in the Strassfurt, Germany salt mines changed this methodology. Today potassium hydroxide is produced through the electrolysis of potassium chloride brine. Subsequently, the KOH is carbonated with carbon dioxide to form potassium carbonate.

K_2CO_3 is the chemists' short-way of representing potassium carbonate or PotCarb as it is commonly called today. Although it is known by several other names, the chemical formula is the most definitive way to confirm this compound. Some of alternate nomenclature that may be used includes: PC, carbonate of potash, pearl ash and carbonic acid, dipotassium salt.

In everyday chemical technology, the choice between potassium and sodium carbonate is decided on the economics or some desired physical / chemical property. The principal reasons to utilize potassium carbonate are:

- source of potassium ion
- buffered alkalinity
- greater solubility for potassium vs. sodium carbonate
- potassium ion is more reactive than sodium ion
- replacement for sodium sensitive applications
- enhances fluxing properties of glass
- depresses freeze point of water, allowing cold temperature applications

In the past, the use of a hydrated potassium carbonate (16% water) was preferred to the more deliquescent anhydrous form. Technology has since spurred improvements in several areas, thereby fostering the acceptance of the anhydrous granular form of potassium carbonate. These improvements include the development of other PotCarb processes and enhancements in the areas of packaging, dry bulk handling and storage facilities.

One commonly used method produces a calcined PotCarb that requires several additional processing steps after its liquid phase reaction between caustic potash and carbon dioxide. The final step being a heat treatment where the temperature is raised sufficiently to drive off the water of crystallization. Two different ion exchange methods each employ a multi-step process that requires several raw materials and also yields several by-products. A more practical approach for supporting the use of anhydrous potassium carbonate is the development of the fluidized bed reactor. This

process allows the direct, one-step manufacturing of an anhydrous material that needs no further refinement. Typically there is much greater customer demand for dry material, however, since PotCarb it is readily soluble, aqueous solutions do not present a challenge. Armand Products is well positioned to meet the demands of today's customers with its four state-of-the-art fluidized bed reactors and its liquid PotCarb capabilities.

II. Markets and Uses of Potassium Carbonate

The potassium carbonate market is divided between the glass industry and other numerous applications. Product is shipped throughout the United States and into international regions.

Video glass accounts for 44% of potassium carbonate usage, while specialty glass and ceramics use 10%. The main reason that relatively expensive potassium carbonate is used in place of soda ash in glass applications is that it is more compatible with the required lead, barium and strontium oxides. These specialty glasses possess the improved properties of greater electrical resistivity, higher index of refraction, greater brilliance or luster, lower softening point and a wide temperature working range. In addition, potassium carbonate allows improved behavior of many colorants in glass.

Potassium carbonate has a wide variety of uses outside of the glass industry. Major applications that account for 46% of the PotCarb produced include but are not limited to: potassium silicate, pharmaceuticals, food, detergents and cleaners, photographic chemicals, agricultural, gas purification, rubber additives, polymer catalysts, potassium bicarbonate, cement and textiles.

A more complete summary of the various uses of potassium carbonate is given in the following table:

POTASSIUM CARBONATE APPLICATIONS

GLASS	CHEMICALS	DYES PIGMENS	FOOD	CLEANERS	GAS PURIFICATION	OTHER
Source of K_2O for alkali barium, lead or strontium silica glasses used in the production of television tubes, illuminating ware, tubing, laboratory glass, optical glass, tableware, and giftware. Used alone or with Na_2CO_3.	Inorganic chemicals	Inks	Chocolate "alkalyzing" or "Dutch" processing of cocoa powder	Washing	Removal of carbon dioxide and other acid gases by absorption in a solution of potassium carbonate. With the following materials:	Tanning leather
CERAMICS	Potassium salts of phosphates, silicates, persulphates, permanganates, and potassium cyanide antioxidants	Dry Colors	Effervescent mineral water	Bleaching	1. natural gas	Perfume and toilet articles
Used especially in titanium dioxide frits for appliance industry	Oxalic acid	Dyeing Textiles	Special leavening agents	Boiler compounds	2. synthesis	Refrigeration
	Dehydrating agents	Printing Fabrics	Brewing beer	Liquid soaps	3. hydrogen	Fire extinguishers
	Corrosion inhibitor		Raisin drying	Metal cleaners	4. synthetic natural gas	Photography
	Fertilizers		Alfalfa drying		5. petrchemical products	Flameproofing
	Catalysts		Cattle feed additive		6. dry ice	Electroplating
	Drugs		Oriental noodles		7. chemicals from hydrocarbon gases	Molten salts
	Gums				8. Molten carbonates for removal of sulfur dioxide from flue gases	Fireproof coolant as in anti-freeze for exposed steel columns
	Adhesives					Rubber additives
	Terephthalic acid					
	Rocket fuels					

III. Manufacturing Process

Armand Products' Potassium Carbonate is manufactured in a fluidized bed reactor at its production facility in Muscle Shoals, AL. This results in a product that is anhydrous, making it unnecessary to perform any further processing to eliminate hydrated water (calcining). Armand Products' Potassium Carbonate (PotCarb) is a white, dense, free-flowing granular material which is easy to handle and store.

The process starts with potassium chloride, obtained from the Canadian province of Saskatchewan. Through an electrolytic conversion of the KCl salt, potassium hydroxide (caustic potash, KOH), chlorine (Cl_2) and hydrogen (H_2) are produced. The hydrogen is a fuel source while the chlorine has numerous important and varied applications. Liquid caustic potash and carbon dioxide are the only raw materials required for producing PotCarb.

The dry potassium carbonate can easily be dissolved in water to form a liquid solution. Typically a 47% solution is recommended as this capitalizes on the highest concentration with the lowest freezing point (3°F). This minimizes handling problems during colder weather.

The chemical equation for this process is simply:

$$2\,KCl + 2\,H_2O \rightarrow 2\,KOH + H_2 + Cl_2$$

$$2\,KOH + CO_2 \rightarrow K_2CO_3 + H_2O$$

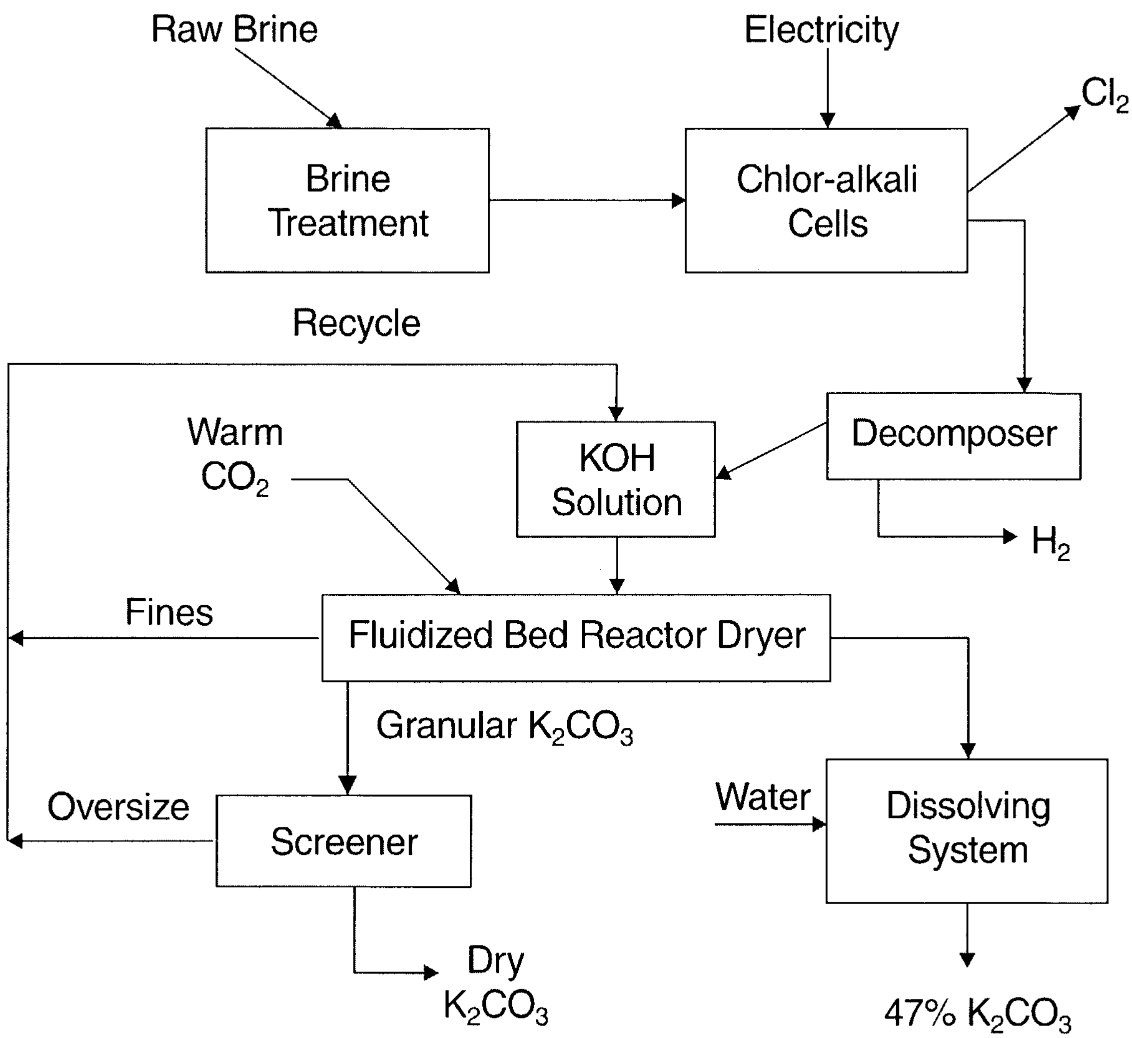
The favorable logistics of this production facility cover a wide spectrum of advantages:

- Largest domestic facility, utilizing four reactors in two plants;
- Dry and liquid forms available in various packaging units;
- Vertically integrated with on-site production of liquid caustic potash (KOH), the key raw material;
- Geographical location in proximity to Gulf and Eastern coast ports, allowing for timely export shipments;
- Electric power for raw material conversion and plant operations is readily available from a nearby TVA plant.

As a side note, potassium carbonate cannot be made by the Solvay process used for sodium carbonate (Na_2CO_3).

The flow diagram for the manufacturing process is shown on the next page:

Flow Chart of Manufacturing Process



IV. Grades of Potassium Carbonate

Armand Products produces potassium carbonate in granular and liquid form to satisfy the requirements of its customers. Each material conforms to the high standards of chemical purity and physical properties essential for our extensive and varied customer base. Armand Products' anhydrous potassium carbonate is white, dustless, dense, free-flowing granular product. Several grades of dry PotCarb that differ in their typical granulation ranges are available. In addition, a water solution in the form of a 47% solution is typically provided.

Requests can be made through the Armand Products' Technical Service staff for the following literature:

Sales Specification
product grade sheets listing parameters and their limits

Technical Information
data sheets covering chemical and physical properties

The chemical parameters included in the standard sales specifications for Anhydrous Potassium Carbonate are:

K_2CO_3	KOH
KCl	H_2O
Na	K_2SO_4
As	Fe
Hg	Ni
Heavy Metals (as Pb)	

Physical Properties:
(not specification items)

Particle Size
Typically material is between 18 and 80 mesh for granular and through 325 mesh for ground material.

Bulk Density
75 - 84 lb/ft^3 (granular, varies by grade); 37 lb/ft^3 (extra fine)

Melting Point
891°C

Solubility in Water
112 grams in 100 grams water at 20°C

Appearance
White, granular, free-flowing

V. Materials of Construction

Iron, steel, stainless steel, rubber lined steel or phenolic lined steel is recommended.
If heated to 120°F, the potential for iron contamination exists.
Polyethylene drums can be used for liquid storage and handling at ambient temperatures.
Aluminum, zinc, brass, bronze, and copper are **NOT** recommended due to the potential for a reaction.

Experience with the various polymeric materials of construction is limited. Additional data based on customers' own experiences should be considered. The weight of the PotCarb must be factored into the structural constraints of polymeric materials. The following information is therefore offered as a starting point:

- Polyethylene and propylene can be used if not exposed to temperatures beyond that recommended for each polymer. Possible deformation of polymer surface may occur. Caution is advised during processes that generate heat, e.g., solubilization of dry potassium carbonate.
- Polyester is NOT recommended.
- Polyvinyl chloride (PVC) has been reported to be acceptable but caution is advised for possible embrittlement. Regular inspection and proper usage procedures may allow good service from this material.

A. ANHYDROUS POTASSIUM CARBONATE

Piping

Pneumatic systems require 4 inch minimum piping with four foot radius curves. Gravity feed systems should be 6 inch diameter or larger.

Valves

Butterfly or slide gate valves are typical, however, the butterfly type are preferred for humid conditions.

Blowers

Pneumatic unloading requires blowers that are generally 500 - 600 CFM and operate at 10 lbs. of pressure. In humid conditions, the transfer air should be pulled through a desiccant bed to provide dry transfer air. The dryer should be checked periodically and replaced as needed.

Storage Silos

Capacity should hold at least 1.5 times the size of a normal shipment. A dry air purge in wet humid conditions will ease the handling of product. A 45° slope to the silo bottom is recommended. A bag house is recommended for filtering out dust from the transfer air during the pneumatic unloading of product. Storage silos should be steel, lined steel or stainless. A more thorough discussion of the recommendations for bulk storage can be found in section VIII.D.

B. LIQUID POTASSIUM CARBONATE

Pipelines

A two inch minimum pipeline with a 3 inch minimum on the suction side of the pump is recommended. Long sections of outdoor piping should be heat traced and insulated. Experience has demonstrated that flanged connections with alkali-resistant gaskets will minimized the potential for leaks. All piping should be installed with a slight slope to ensure complete drainage. Loops and pockets are to be avoided.

Pumps

Centrifugal and rotary types with all iron construction may be used. A deep packing gland is desired to prevent leakage at the pump shaft. Graphite/asbestos packing material is recommended for potassium carbonate solution service.

Valves

Globe, angle, gate, and plug valves may be employed to control flow rates and for line shutoffs. Valve construction of cast iron, steel, and stainless steel (Type 316 and 304) is recommended.

Storage Tanks

Fabrication specifications require at least 3/8 inch wall thickness for units larger than 10,000 gallon capacity and a 1/4 inch wall for smaller capacities. The withdrawal pipe connection should be a few inches above the bottom of the tank. To facilitate tank cleaning, a drain connection should be installed at the lowest point in the tank.

Rubber or phenolic based epoxies can be used for lining steel storage tanks where prevention of iron contamination is critical. However, rubber does not withstand high temperatures.

Storage tanks in cold climates should be insulated with 2 inches of polyurethane insulation to maintain pumpable conditions and should have an internal or external heat source to make temperature adjustments.

Some plastics are also acceptable for small tank construction (generally less than 10,000 gallons). Polypropylene, polyethylene, PVC, CPVC and FRP can be used. Polypropylene is the most commonly used plastic for storage tanks.

Further discussion with our Technical Service staff on the appropriate materials of construction and equipment for handling potassium carbonate is encouraged.

VI. Shipping Packages

SHIPMENT OF POTASSIUM CARBONATE

Potassium carbonate can be shipped in various types and sizes of packaging. Armand Products' Technical Service is available to discuss all possible options and can assist the customer in determining the most advantageous method to receive this product. Examples of the typical containers available are:

- 50 and 100 pound multiwall paper bags
- 400 pound fiber drums
- 2000 pound bulk bags
- hopper and pneumatic trucks
- hopper and pneumatic railcars

Factors that determine the type of package include the quantity to be used, as well as the customer's location, unloading system and storage facilities. Since bulk shipments can be made in trucks and railcars, it is better to determine the most advantageous delivery method through an economic survey for each individual case.

BAG AND DRUM SHIPMENT

The multiwall kraft bags used by Armand Products are constructed with a polyethylene moisture barrier to better protect product quality during storage. Fiber drums can be furnished with a polyethylene liner upon request. Bag and drum specifications are available from Armand Products' Technical Service department.

Although receipt of the material in bags or drums may not offer the economic advantage of bulk, there are other factors which may prompt the choice of this type of packaging. The use of bags or drums simplifies distribution when potassium carbonate is used in small quantities at several locations. Individual packages also eliminate the necessity of batch weighing potassium carbonate for various requirements. No expensive or elaborate equipment is needed to unload or handle bagged or drummed potassium carbonate shipments. The use of drums and bags makes potassium carbonate available to even the smallest industrial consumer.

Trucks and rail cars for this service are checked internally for the presence of moisture, previously loaded material, and general surface deterioration.

BULK BAG SHIPMENT

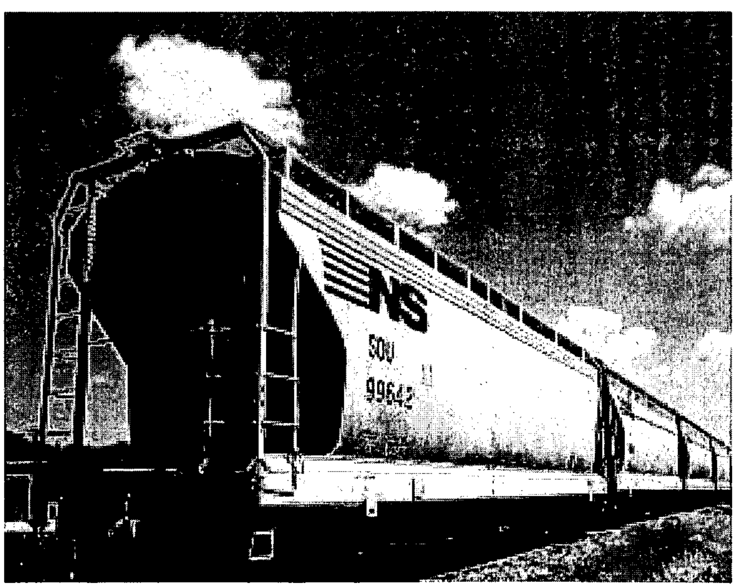
This larger form of individual packaging offers a unique advantage for those that meet the space requirements but do not have the capability to unload and store truck or rail car shipments. Typically each bag is filled with 2,000 pounds of potassium carbonate. For truckload quantities however, different weights can be filled to meet the customer's batch requirements. These bulk bags are made of a woven polypropylene fabric with a polyethylene liner as a moisture barrier. This is considered a one trip package to ensure the safe handling integrity of the bag and to maintain product quality. Bulk bags filled with a metric ton (2205 pounds) of product have become the preferred package for export shipments.

BULK SHIPMENT

Bulk quantities of potassium carbonate may be shipped in covered hopper cars, pneumatic unloading cars, hopper trucks, or self-unloading pneumatic trucks. The choice depends on the quantity used, as well as the customer's location, unloading system and storage facilities. Details of the various options can be discussed with Technical Service personnel.

Covered hopper cars are specially designed to handle products such as potassium carbonate and provide the most satisfactory method of bulk shipment. These self-discharging cars are equipped with weatherproof hatches and three or four bottom outlet gates which provide protection from outside contamination. The bottom outlets are normally of the Enterprise or sliding gate type, measuring 13 x 24 or 13 x 42 inches, with a clearance of 6 to 9 inches over the rail that will vary with car design. Hopper cars, normally available in 70 and 95 ton capacities, can be readily adapted to mechanical unloading systems.

Pressure differential (PD) railroad cars are available to customers who have an appropriate pneumatic system in place to handle unloading. Those who have a potential interest in receiving PD bulk railcar shipments are invited to discuss this option with Armand Products' Technical Service.



Motor truck shipments have been found practical for bulk potassium carbonate, particularly where the distance is not excessive and the customer's consumption or location will not allow rail deliveries. The amount of material that can be carried is usually restricted by the road limitations of the states through which the haul is made, with a typical maximum weight of 45,000 pounds. Truck designs can vary but hopper bottom discharge or self-unloading pneumatic trucks are typical.

The development of self-unloading trailers now enables consumers of as little as 100 tons per year to receive potassium carbonate in bulk without the necessity of providing costly unloading equipment. The tank-type trailer available for this service carries a self-contained unloading system which blows the material into the customer's bin. (**Figure 1, Page 15**) It is operated by the driver, who makes the complete delivery. The receiving equipment required by the customer is relatively simple in structure and is easy to install. It consists of a vertical transmission line made with a four inch standard pipe and four foot radius bends with a tank vent through a filter system to remove dust.

Since shipments of potassium carbonate will be 20-23 tons by this service, a minimum storage capacity of 30-35 tons will usually be adequate for most plants. Conventional silos, tanks or existing storage facilities can easily be adapted for this system. The facility must be moisture-tight and requires a storage tank vent dryer.

Anhydrous and liquid forms of